INVESTIGATION OF FIVE DIFFUSE STAR CLUSTERS

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ABSTRACT. This paper discusses the results of an investigation of the diffuse star clusters NGC 1502, NGC 2422, NGC 7380, NGC 7788, and 7790. Three criteria are used in determining whether a star is a cluster member. These criteria are:

1. the position of the star in the color-stellar magnitude diagrám, [V, (B - V)];
2. its position in the two-color diagram, [(U - B), (B - V)];
3. the star's proper motion.

The proper motion criterion was applied by means of Ebbighausen's method. In those cases where the interstellar absorption was found to vary from point to point across a cluster, the individual color excesses of the stars were considered.

Basing his work on the above criteria, the author found that 38 stars were definite members of the cluster NGC 7788. For the cluster NGC 7790, 30 stars satisfied the three criteria for cluster membership. A Cepheid variable, CF Cas, and an eclipsing variable, QX Cas, were found to be members of this cluster. The cluster NGC 2422 was found to have 45 definite members, one of which is a giant star. In the case of the cluster NGC 1502, 35 stars were found to be members. Finally, in the case of the cluster NGC 7380, 25 stars turned out to be definite cluster members.

In addition the author calculated the absolute proper motions and tangential velocities of these clusters corrected for the solar motion. Then using the known radial velocities, the total space peculiar velocities of the clusters in question were calculated.

In the present paper the results are presented for an investigation of /3* the diffuse star clusters NGC 1502, NGC 2422, NGC 7380, NGC 7788, and NGC 7790 as well as their proper motions determined on the basis of a catalogue of proper motions of the stars of these clusters and in their vicinity [1-3]. In the regions of the clusters NGC 7788 and NGC 7790 the proper motions of the stars were first determined by the author of the present paper. The proper motions of 146 stars in the region of the cluster NGC 1502 were determined

* Numbers in the right margin indicate pagination in the foreign text.

previously by Hopmann [4]. However, the observational material used by him was obtained with various instruments, which naturally affected the accuracy of the results. In the region of the cluster NGC 7380 the proper motions of the stars were determined by Li Hen [5], but in his paper there is no list of the members of the cluster and the proper motion of the cluster was not determined.

The proper motions of 2942 stars to the 16th photographic magnitude are presented in papers [1-3] in the five regions of the sky containing the investigated stellar clusters. All five clusters are provided with three-color photometric data determined by Sandage (NGC 7799), Becker (NGC 7788), and Hoag and others (NGC 2422, NGC 1502, NGC 7380).

Method of selection of the stellar members of a cluster. The method of selecting members of a cluster from the stars of the background plays a significant role in determining the proper motions of a diffuse star cluster, since even in the central parts of these clusters a significant number of background stars can be projected.

At present the choice of the members of a cluster is carried out with the aid of proper motions and photometric characteristics of the stars in a given region of the sky. Although many star clusters have been thoroughly investigated photometrically, the same cannot be said regarding their proper motions. To carry out the selection of the members of a cluster we used a method worked out at the Pulkov Observatory [20].

According to this method, the membership of each star in a cluster is determined on the basis of three criteria: the criterion of proper motions and two photometric criteria for which the position of a star in the color-stellar magnitude diagram [V, (B - V)] and in the two-color diagram [(U - B), (B - V)] serve. /4

The method proposed by Ebbighausen [6] is used to exhibit the membership of a star in the cluster based on its proper motion; in addition, in the case of selection in regions of the sky where the value of the interstellar absorption varies from point to point we included the individual color excesses of the stars.

It is known from papers [7,8] that in the regions of the sky containing star

clusters NGC 7788, NGC 7790, and NGC 2422 the interstellar absorption is a constant. Therefore for each of these regions they constructed a color-stellar magnitude diagram [V, (B - V)] and a two-color diagram [(U - B), (B - V)] without taking into account the individual color excesses of the stars: the stars situated on the main sequence or in the giant and supergiant regions were taken as probable cluster members.

For stars in regions of the sky with the stellar clusters where the interstellar absorption is not constant and for stars which have UBV photometry they first found V and the color index (B - V) corrected for reddening and the total interstellar absorption of light and then constructed from them the color-stellar magnitude diagram. Thereupon they calculated the value of the total interstellar absorption in the V region from the formula

$$A_V = 3E_{(B - V)},$$

where

$E_{(B - V)}$ is the color excess in the (B - V) color index.

In contrast to the observed V and (B - V), the values corrected for reddening and total interstellar absorption of light are denoted as V_0 and $(B - V)_0$. They carried out the selection of cluster members from the $[V_0, (B - V)_0]$ diagram and the individual color excesses of the stars. They did not consider the star as a probable cluster member if its color excess stood out sharply among the color excesses of the stars closest to it, differing from the average value of the color excesses by an amount larger than the amplitude of variation of $E_{(B - V)}$ over the total area of the cluster.

With the aid of cluster members thus selected they carried out the final selection of the stars of the cluster. For this, according to Ebbighausen, they constructed a vector diagram from the components of the proper motions of the selected stars. Along the X-axis they plotted μ_x, and along the Y-axis, μ_y. Then as is well known, the members of the cluster should form a compact group around some point whose coordinates evidently should correspond to the average value of the proper motions of all the stars of this group. For selection of the cluster stars in the first approximation by proper motion of the cluster we assume the coordinates of this point, then describe around it three concentric circles having radii corresponding to $r_1 = \sqrt{2}\,\sigma$, $r_2 = 2\sigma$, $r_3 = 2\sqrt{2}\,\sigma$

(σ is the mean square error of a single proper motion of a star).

The stars whose proper motions corresponded to points within the first circle were considered to be the most probable cluster members; the stars corresponding to points located between the first two circles were considered probable members of the clusters. And finally the stars whose proper motions corresponded to points situated between the second and third circles were considered as probably belonging to the background. Evidently all stars whose proper motions in the vector diagram corresponded to points located beyond the limits of the circle of radius $r_3 = 2\sqrt{2}\,\sigma$, should belong to the background.

The application of both methods of selection gave us the possibility of more certainly distinguishing cluster members. /5

Clusters NGC 7788 and NGC 7790. The clusters in question are projected on the celestial sphere not far from one another. On a photograph taken with a normal astrograph the distance between centers of these clusters was equal to 14 mm. Their equatorial coordinates are the following (epoch 1950.0):

for NGC 7788, we have $\alpha = 23^h54^m.2$, $\delta = +61°07'$,
for NGC 7799, we have $\alpha = 23^h55^m.9$, $\delta = +60°57'$.

The proper motions of the stars of these clusters are indicated in the paper [1].

The accuracy of the proper motions of the stars is characterized by their probable errors. For the clusters in question they are:

$$\varepsilon_x = \pm 0''.0018 \quad \text{and} \quad \varepsilon_y = \pm 0''.0020$$

The observational material for the regions under discussion is given in Table 1 of the paper [1].

The photometric data of the stars in the region of the cluster NGC 7788 are contained in the papers [8-10 and others]. K.A. Barkhatova [9] presents the results of photographic determinations of V and (B - V) for 98 stars and (U - B) for 24 stars. I. E. Alekseyev [10] determined from photographs obtained at the Shternberg Astronomical Institute photographic magnitudes for 113 stars and their connection with the B system in the region of the diffuse star clusters NGC 7788 and NGC 7790. As a standard for obtaining the photographic magnitudes of the stars he used 40 stars from the region of NGC 7790, whose magnitudes were determined by Sandage [11] as a result of photographic and photoelectric observations

on the UBV system.

Three-color photometry on the UBV system for stars in the region of the cluster NGC 7788 was carried out by Becker [8]. In all he measured 113 stars of which accurate three-color photometry was carried out for 63 stars (the remaining 50 were too faint to obtain ultraviolet magnitudes). On the basis of these measurements Becker carried out a selection of cluster members from the background stars. As a result 60 stars appeared to be members and two stars, doubtful members of the cluster. In addition, the constancy of the value of the interstellar absorption was established by him. Below are presented some data from this paper, where the true distance modulus, i.e. corrected for the effect of reddening and total interstellar absorption, is denoted by (m - M); the distance from the sun in parsecs by R, and the average color excess in the region of the cluster by $E_{(B-V)}$:

m - M	R	$E_{(B-V)}$	Cluster diameter		Diameter of the nucleus	
			apparent	linear	apparent	linear
$11^m.91$	2410	$0^m.28$	9'	6.3 pc	3'	2.1 pc

We measured 67 stars from Becker's list (46 faint stars were not obtained on our photographs). The color-stellar magnitude diagram is shown in Figure 1 and in Figure 2, the two-color diagram for members of the cluster NGC 7788 based on the photometric data of Becker. The [V, (B - V)] and [(U - B), (B - V)] diagrams are constructed for the 67 stars measured. According to their position 19 stars deviate significantly from the main sequence.

Thus according to the photometric criterion, 48 stars can be taken to be probable members of the cluster. Among them we carried out the selection of cluster members by Ebbighausen's method [6]. The vector diagram is given in Figure 3, where the radii of the three concentric circles were obtained as follows: /6

$$r_1 = 0.^{\circ}0040, \quad r_2 = 0.^{\circ}0056, \quad r_3 = 0.^{\circ}0079.$$

As a result of the selection, it was clear that on the basis of proper motions only 38 stars could be cluster members. Stars 69 and 108 (numbers according to Becker) deviated considerably from the main sequence on the

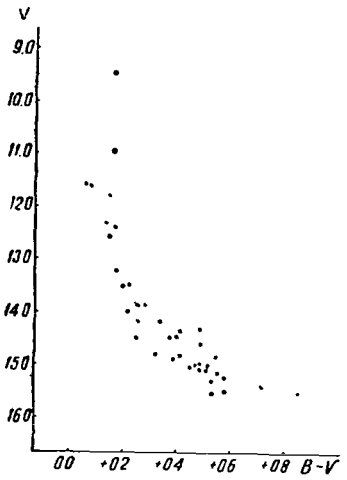

Figure 1.

[(U - B), (B - V)] diagram, although on the [V, (B - V)] diagram and the vector diagram one could assign them as cluster members with assurance. The (U - B) color indices of these stars are probably determined with insufficient accuracy. On this assumption we incorporated them into the list of cluster members (Table 1). The remaining 10 stars (28, 39, 42, 47, 52, 53, 74, 95, 102, and 110) according to the proper motion criterion cannot be cluster members.

In Table 1 the number of the stars according to Ishmukhamedov's catalogue [1] are denoted by $No._I$, the number in Becker's catalogue [8] by $No._B$; m_I is the photographic stellar magnitude from the paper [1]; m_B is the photovisual magnitude: CI_B is the color index; μ_x, μ_y are the annual proper motion. The proper motions of the stars are presented in this paper to four decimal places without rounding off. Therefore in what follows we will use the proper motions of the stars without rounding off.

The probable members of the cluster NGC 7788 are given in Table 2.

The stars located within the limits of the apparent boundaries of the cluster which according to the proper motion criterion can be cluster members are entered here. These stars are denoted by circles on Figure 3.

The relative proper motion of the cluster NGC 7788 is obtained as the average value of μ_x and μ_y of the definitely selected cluster members, i.e. stars included in Table 2. It turned out to be:

$\bar{m}$	$\bar{\mu}_x$	$\bar{\mu}_y$	n
$14^m.2$	$-0''.0008$	$-0''.0002$	38
	$\pm 0''.0007$	$\pm 0''.0003$	

where

$\bar{m}$ is the average stellar magnitude of the cluster members;

n is the number of cluster members; and the probable errors of μ_x and μ_y are shown under their values.

They were determined from the deviations from the average value of the proper motions of the cluster calculated from separate pairs of plates.

Sandage [11] carried out photometry on the UBV system of the stars in the region of the cluster NGC 7790 with the aid of photoelectric and photographic observations. He determined U, B, and V magnitudes for 22 stars and B and V for 78 stars. According to this work the interstellar absorption in the region occupied by the cluster has a constant value equal on the average to $\overline{A}_V = 1^m.56$. /7

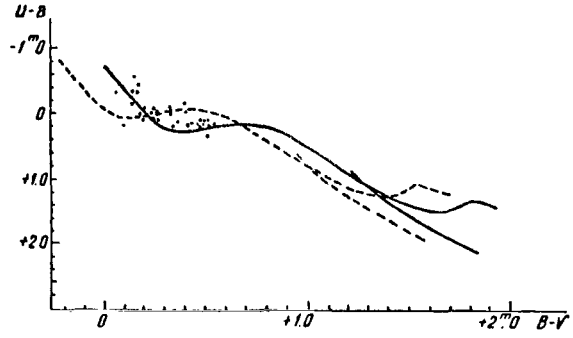

Figure 2.

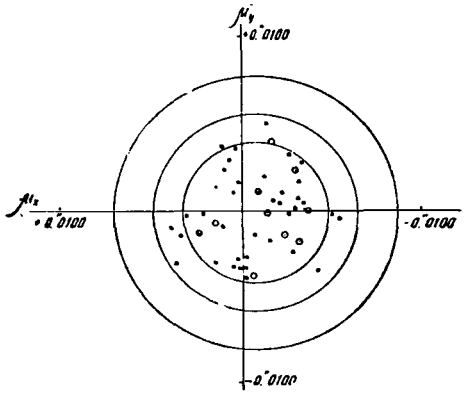

Figure 3.

In addition, for seven stars of the cluster in question he gives $E_{(B-V)}$, the individual color excesses, $M_V(S_p)$, the spectroscopic absolute stellar magnitude, (m - M), the apparent distance moduli, and S_p, the spectral type (Table 3).

The results of a discussion based on UBV photometric data for 106 diffuse star clusters are presented in the paper [7]. We present below some data from the paper [7] for the cluster NGC 7790:

m - M	R	$E_{(B-V)}$	$(B-V)_T$	S_p
$12^m.8 \pm 0^m.3$	3600	$0^m.52$	$-0^m.18$	B 4

where

$(B-V)_T$ is the point on the color-stellar magnitude diagram where the main sequence of the star cluster turns to the right;

S_p is the spectral type of the stars lying at the point $(B-V)_T$.

The remaining notations are the same as in Table 1. The turning point $(B-V)_T$

is determined as the color index $(B - V)_0$ of the earliest main sequence stars among the cluster members corrected for reddening and expresses the evolutionary effect in the color-stellar magnitude diagram.

From $(B - V)_T$ and the spectral class of the stars lying at the point $(B - V)_T$ the cluster NGC 7790 appears to be rather young. In this same region are situated the four variable stars CE Cas_a, CE Cas_b, CF Cas, and QX Cas. The first three of them are Cepheids, and the remaining one is an eclipsing variable. On our photographs the images of the Cepheids CE Cas_a and CE Cas_b were blended so that it was not possible to determine their individual brightnesses. Therefore the proper motion of star 705 given in our catalogue cannot be considered reliable.

TABLE 1

No.$_I$	No.$_B$	m_I	m_B	CI_B			
				$B-V$	$U-B$	μ_x	μ_y
351	21	$15^m.5$	$15^m.11$	$0^m.52$	$+0^m.19$	$+0''.0010$	$-0''.0010$
372	59	15.1	14.86	0.42	+ 26	+ 1	− 29
379	54	16.0	15.42	0.73	—	− 2	− 28
384	34	13.6	13.58	0.21	− 05	− 32	+ 6
391	55	16.0	15.54	0.54	—	− 1	− 33
394	2	12.6	12.62	0.15	− 04	− 35	+ 3
395	12	15.7	15.26	0.58	− 04	− 34	+ 27
396	13	15.6	15.14	0.56	—	− 7	− 15
400	56	15.7	15.32	0.53	—	− 13	+ 19
402	36	14.6	14.54	0.25	+ 17	+ 3	+ 36
404	1	9.5	9.49	0.16	− 30	+ 9	+ 22
405	7	15.4	15.00	0.51	+ 17	− 18	+ 5
406	11	14.8	14.52	0.37	+ 20	− 49	− 2
412	10	11.5	11.63	0.05	− 29	+ 21	− 2
413	5	12.3	12.34	0.14	− 28	− 15	+ 49
420	38	16.0	15.52	0.59		− 27	+ 32
428	50	13.3	13.24	0.25	00	− 22	+ 4
429	61	15.5	15.08	0.53	+ 41	+ 30	− 4
433	48	14.1	14.03	0.22	+ 09	− 23	+ 9
435	62	14.3	14.19	0.26	+ 04	− 2	− 40
440	112	14.7	14.39	0.46	+ 25	− 32	+ 16
445	40	14.4	14.21	0.34	+ 24	− 29	− 26
446	91	15.3	14.85	0.55	+ 21	00	− 34
459	91	15.3	14.85	0.55	+ 26	− 55	− 5
461	90	16.0	14.78	0.33	+ 01	+ 13	+ 13
464	73	13.6	13.49	0.22	+ 10	− 27	− 3
467	74	14.3	14.18	0.25	+ 06	+ 33	− 16
471	67	14.7	14.29	0.50	+ 31	+ 10	+ 36
476	69	14.8	14.50	0.40	− 11	+ 4	− 33
481	94	15.1	14.88	0.40	+ 05	+ 4	+ 10
482	97	14.0	13.88	0.28	+ 19	+ 6	+ 28
483	71	11.0	10.98	0.17	− 53	− 16	+ 19
484	88	15.3	15.01	0.46	+0.26	+ 01	+ 15
489	99	14.0	13.89	0.26	+ 02	+ 14	− 31
497	85	14.9	14.57	0.49	+ 33	− 31	+ 1
381	108	11.6	11.64	0.08	+ 13	+ 16	− 23
468	68	11.8	11.86	0.15	− 47	− 41	− 35
505	101	12.5	12.49	0.18	+ 04	+ 36	− 32

The Cepheid CE Cas and the eclipsing variable QX Cas (corresponding to stars 750 and 840 in our catalogue) were investigated by Sandage [11]. His period and amplitude of brightness variation for the Cepheid CF Cas were found to be the same as in an earlier paper [12]. The amplitude of brightness variation in the V system amounts to $0^m.5$ for the star QX Cas. The period of brightness variation cannot be determined from Sandage's observations.

Kraft [13] presents spectral and photometric data for eight stars in the region of the cluster NGC 7790. On the basis of the data for CF Cas he considers it to be a cluster member.

We constructed the color-stellar magnitude diagram and the two-color diagram from the photometric data of Sandage [11]. Based on the photometric indications, 35 stars, for which he constructed the vector diagram using their proper motions, appeared to be members of the cluster. As a result of the selection 30 stars appeared to be cluster members; they are presented in Table 4, where the numbers of the stars according to Sandage's list [11] are denoted by $No._S$; m_I is the photographic stellar magnitude [1]; V is the photovisual stellar magnitude; (B - V) and (U - B) are the color indices [11]; S_p is the spectral type [11]; $M_V(S_p)$ is the absolute stellar magnitude; and μ_x, μ_y are the annual proper motions expressed in $0''.0001$. According to the position of stars 750 and 840 on the [V, (B - V)] and [(U - B), (B - V)] diagrams, and particularly in the vector diagram, they appear to be cluster members.

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TABLE 2

No.$_1$	m_1	μ_x	μ_y
338	$15^m.4$	$-0''.0015$	$-0''.0002$
375	14.1	— 32	— 19
377	14.1	— 24	— 16
398	11.7	— 31	+ 22
399	11.7	— 10	+ 10
424	15.5	+ 23	— 14
436	14.9	— 18	+ 38
454	15.6	+ 14	— 14
493	13.8	— 06	— 38
535	15.3	— 37	00

TABLE 3

№$_S$	№$_I$	S_p	$M_V(S_p)$	V	$m-M$	$E_{(B-V)}$
A	692	B 2 III—IV	$-3^m.2$	$11^m.08$	$14^m.28$	$0^m.51$
D	724	B 9 III	—2.0	12.59	14.59	—
B	768	B 5 IV	—2.2	12.79	14.99	50
O	811	B 9 IV	—1.0	13.54	14.54	51
40	796	B 8 IV	—1.7	13.07	14.77	34
95	784	B 5 IV	—2.2	12.67	14.89	46
99	789	B 7 IV	—1.8	13.34	15.14	50

Stars 886, 232, 835, 847, and 889 appeared in the vector diagram beyond the limit of the circle having radius r_3; we assigned them to the list of background stars. Based on proper motion and position in the sky, there are still six stars which can be considered cluster members, but on the color-stellar magnitude diagram they deviated from the main sequence. We do not have available other photometric data besides that described above, so we cannot categorically state that these stars belong to the cluster; they are given in Table 5.

The color-stellar magnitude diagram and the two-color and vector diagrams based on the proper motions of the stars of the cluster NGC 7790 are presented in Figures 4, 5, and 6, respectively. The relative proper motion of the cluster NGC 7790 was obtained as the average of μ_x and μ_y for the individual stars from Table 4. It was found to be:

$\bar{m}$	$\bar{\mu}_x$	$\bar{\mu}_y$	Number of stars
$14^m.0$	-0".0008	-0".0004	30
	±0".0007	±0".0006	

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Here the probable error is presented and $\bar{m}$ is the average stellar magnitude of the cluster members.

TABLE 4

№ I	№ S	m_I	V	$B-V$	$U-V$	S_p	$M_V(S_p)$	μ_x	μ_y
670	88	$15^m.2$	$14^m.89$	$0^m.45$	$-0^m.19$			+0".0005	+0".0013
691	86	14.3	14.02	0.45				— 6	— 3
692	*A*	12.2	11.8	0.24	—0.63	*B*2 V	—3.2	— 25	— 17
699	87	13.9	13.68	0.37	—0.21			+ 22	— 13
702	*J*	13.6	13.30	0.46	+0.36			— 7	— 23
724	*D*	12.8	12.68	0.31		*B*9 III	—2.0	+ 1	0
731	63	15.1	14.84	—0.39	—0.03			— 40	— 17
736	62	13.6	13.32	0.41	+0.10			+ 15	+ 16
741	*B*	12.6	12.16	0.41	+0.02			— 22	— 14
744	61	15.0	14.67	0.44	—0.13			— 14	— 7
756	*Q*	14.1	13.81	0.42	—0.07			+ 8	— 26
757	*x*	15.0	14.62	0.46	—0.08			— 19	— 12
758	82	15.6	15.18	0.52				+ 14	+ 13
759	24	15.6	15.32	0.42				— 10	— 6
772	*R*	14.3	14.14	0.35	—0.05			— 9	— 11
768	*E*	13.0	12.78	0.36	—0.07	*B*5 IV	—2.2	— 21	— 29
784	95	12.8	12.67	0.33	—0.11	*B*5 IV	—2.2	— 3	+ 19
789	99	13.6	13.34	0.40	+0.03	*B*7 IV	—1.8	— 9	+ 32
790	55	13.2	13.06	0.34	+0.02			— 27	+ 23
796	40	13.2	13.07	0.26	—0.01	*B*8 IV	—1.7	— 29	+ 4
806	52	13.31	13.13	0.33	—0.04			+ 31	— 8
811	*O*	13.7	13.54	0.36		*B*9 IV	—1.0	— 16	+ 1
814	*v*	14.9	14.56	0.44	0.00			— 2	— 48
831	36	13.9	13.66	0.40	0.00			+ 8	— 6
857	*H*	13.5	13.13	0.47	+0.42			+ 9	— 13
800	51	15.1	14.82	0.40	—0.04			+ 8	— 6
860	*U*	15.0	14.52	0.58	—0.24			— 34	— 39
750	*CF Cas*	12.0	11.14	1.24	0.87	*G*0	—3.2	— 24	+ 3
840	*QX Cas*	9.7	10.41	0.28	—0.63	*B*1	—3.6	+ 16	+ 17
813	*M*	13.6	13.32	0.38				— 47	+ 23

Cluster NGC 2422. The diffuse stellar cluster NGC 2422 (equatorial coordinates $\alpha_{1950.0} = 07^h33^m.9$, $\delta_{1950.0} = -14°24'$) is situated in the constellation Puppis. The accuracy of the proper motions obtained by us for the stars in the region of this cluster is equal in x to $\varepsilon_x = \pm 0''.0031$ and in y, $\varepsilon_y = \pm 0''.0035$, and the radii of the concentric circles on the vector diagram of the proper motions corresponding to them have the following values:

$$r_1 = 0''.0069,\ r_2 = 0''.0098,\ r_3 = 0''.0138$$

TABLE 5

№I	№S	m_I	V	B−V	μ_x	μ_y
243	39	$13^m.4$	$13^m.36$	$0^m.16$	−0.0046	+0.0001
767	P	14.3	13.60	0.80	+ 29	+ 3
797	L	13.8	13.23	0.72	+ 13	+ 31
838	G	13.5	13.02	0.62	− 20	+ 20
872	K	14.7	12.98	1.72	+ 2	+ 13
890	4	14.8	13.17	1.66	+ 36	− 2

Photometric investigations of the stars in the region of the cluster NGC 2422 are described in the papers [14, 16]. Zug [14] determined the photographic magnitudes and color indices for 43 stars in the cluster and its vicinity and for 32 stars, individual color excesses. Then based on them he carried out a selection of cluster members. It turned out that one star whose spectral class was KO does not appear to be a cluster member. For the remaining 31 stars, Zug obtained the average value of the color excess in the region of the sky occupied by the cluster. /11

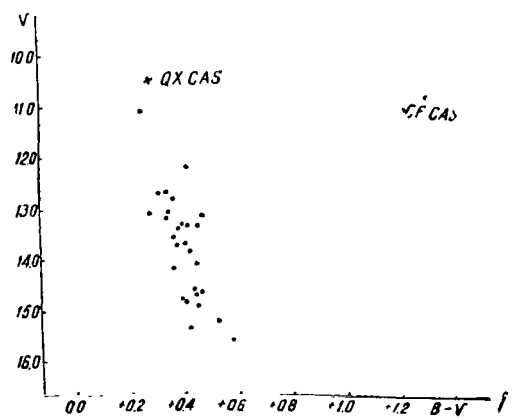

Figure 4

In order to apply the three-color photometry on the UBV system to stars of the southern sky Lynga [15] determined the quantities V, (B - V), and (U - B) of stars in five southern regions of the sky with diffuse star clusters, among which was NGC 2422, for which he presents a stellar map of the region and three-color photometry of 21 stars. The color indices

were obtained by a photoelectric method with the 60-inch Rockfeller reflector of the Boyden Observatory in South Africa.

In the paper [7] are described the results of a photometric investigation of stars in 106 diffuse star clusters. We present below some data from this paper for NGC 2422:

m - M	R	$E_{(B-V)}$	$(B-V)_T$	S_p
$8^m.4 \pm 0^m.2$	480	$0^m.08$	$-0^m.18$	B4

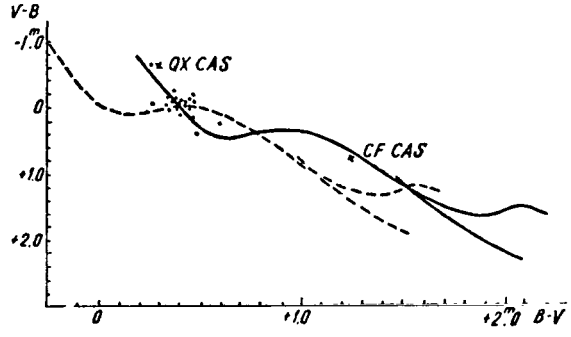

Figure 5.

According to [7], the interstellar absorption in the region of the sky occupied by the cluster is constant and has the following value: $A_V = 0^m.24$.

In the catalogue of the Washington Observatory [16], three-color photometry is presented for 95 stars scattered over a large part of the sky in the cluster NGC 2422 and around it. It includes stars to magnitude $14^m.2$ in the V system. Therefore to select cluster members from background stars according to the photometric criterion, we took the three-color photometry presented in [16]. Of the 95, we measured 75 stars. According /12

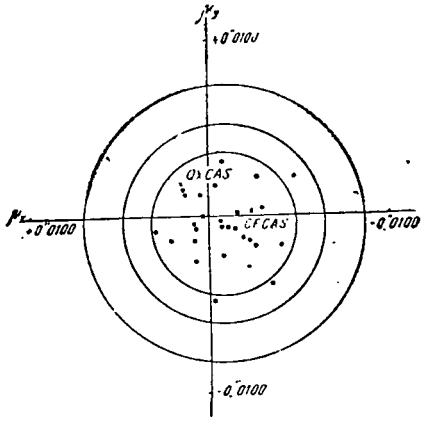

Figure 6.

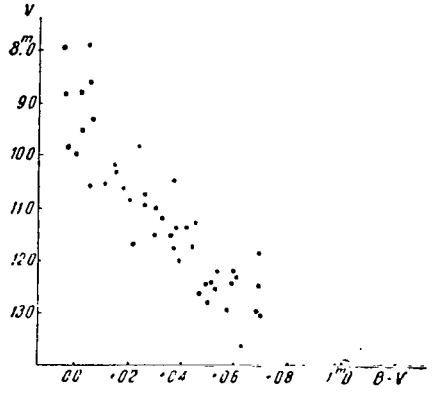

Figure 7.

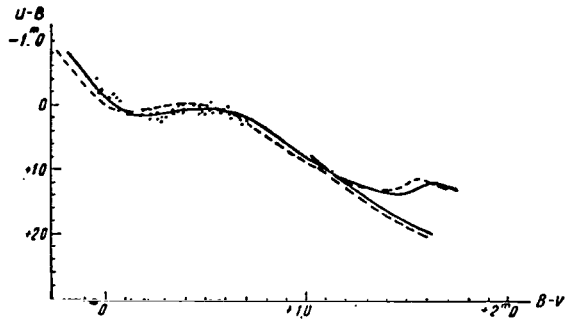

Figure 8.

to the two-color diagram and the color-stellar magnitude diagram constructed by us for cluster members, one can take 53 stars; 20 stars deviated from the main sequence, and stars 266 and 270 (according to our catalogue) were situated in the giant region. The color-stellar magnitude diagram and the two-color diagram are presented in Figures 7 and 8, respectively.

The final selection of cluster members was carried out on the basis of the proper motions of 55 stars. In all, there turned out to be 45 cluster members. One of them (star 266) is a giant. Star 270 was situated on the vector diagram outside the circle of radius r_2 and we assigned it to the background. The vector diagram for cluster members of NGC 2422 is shown in Figure 9, where stars 266 and 270 are denoted by crosses.

A list of the cluster members is given in Table 6; $No._I$, $No._W$, and $No._Z$ /13 are the star numbers from the papers [2],[16], and [14], respectively; the remaining designations are the same as those used in similar preceding tables.

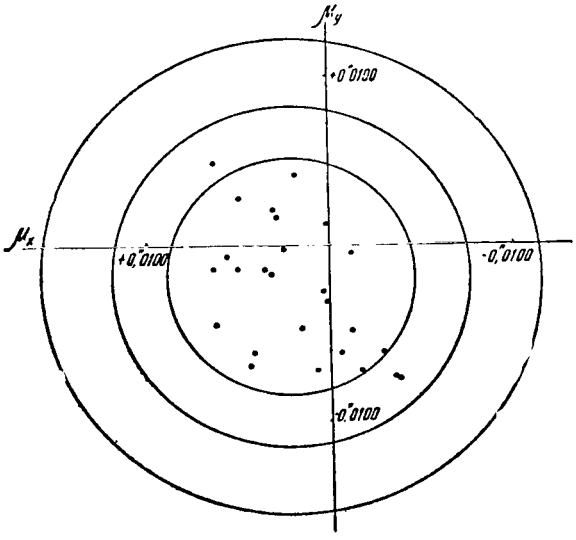

Figure 9.

The relative proper motion of the cluster was obtained as the average of μ_x and μ_y for the individual stars from Table 6:

$\bar{m}$	$\bar{\eta}_x$	$\bar{\mu}_y$	Number of stars
$11.^m3$	$-0.''0025$	$-0.''0025$	45
	$\pm 0.''0003$	$\pm 0.''0003$	

Here and in the regions of NGC 1502 and NGC 7380 the internal probable errors are presented.

The investigation of the proper motions of 138 stars to the $12.^m1$ photographic magnitude in the given region

is described in the paper [17]. Three pairs of plates with a difference of epoch of around 60 years obtained with the 30-cm refractor (f = 5732 mm) of the Bonn Observatory served as the observational material in it. The average error of the proper motions of the stars was found to be ±0".0019 in x and ±0".0024 in y, and 36 stars appeared to be cluster members, two of which the author assigns as doubtful cluster members. In addition, the absolute proper motion of the cluster was calculated in this paper based on the selected cluster members: $\mu_x = -0".0096$, $\mu_y = 0".0024$.

Notwithstanding the fact that in our investigations one pair of plates with a smaller difference in epoch (42.1 years) than in the paper [17] was used, the values of the absolute proper motion of the cluster in our paper and in [17] almost coincide:

$$\mu_x = -0".0064, \quad \mu_y = -0".0008.$$

Cluster NGC 1502. The equatorial coordinates of the diffuse star cluster /14
NGC 1502 are as follows:

$$\alpha_{1950.0} = 04^h03^m.4, \quad \delta_{1950.0} = +62^\circ12'.$$

It is located in the constellation Camelopardus. The accuracy of the proper motions obtained for the stars in the region of the cluster is characterized by the probable errors:

$$\varepsilon_x = \pm 0'.0031, \quad \varepsilon_y = \pm 0'.0035.$$

The average photographic stellar magnitude of the cluster stars is $\bar{m} = 12^m.1$. The radii of the concentric circle on the vector diagram of proper motions calculated on the basis of the probable errors are equal, respectively, to: /15
$r_1 = 0".0069$, $r_2 = 0".0098$, $r_3 = 0".0138$. The photometric investigations in the region of the sky under discussion are presented in the papers [14] and [16].

Zug [14] determined the photographic magnitudes and color indices for 50 stars. Using the spectral classification of Trumpler, he also determined the individual color excesses for 31 stars on the basis of which he carried out

TABLE 6

№I	№W	№Z	m_I	V	$B-V$	$U-B$	μ_x	μ_y	Sp
221	8		$10^m.4$	$10^m.31$	$0^m.26$	$0^m.16$	$-0''.0024$	$-0''.0039$	
234	21		7.8	7.91	0.05		— 20	— 26	
258	49	37	12.0	11.66	0.44	0.03	+ 19	— 37	
271	56		12.8	12.40	0.52	0.08	— 41	— 16	
272	64		13.1	12.76	0.49	0.10	— 1	— 107	
274	11	21	10.5	10.58	0.06	0.08	+ 35	— 37	A3
275	10		10.6	10.60	0.19	0.14	— 45	— 44	
284	15		11.1	10.98	0.30	0.17	— 36	+ 28	
285	17		12.2	12.00	0.39	0.09	— 91	+ 2	
291	52		12.6	12.12	0.60	0.04	— 91	— 22	
292	13	24	10.9	10.81	0.22	0.16	— 33	0	A2
297	48	34	11.7	11.64	0.22		— 53	+ 20	
311	18		13.0	12.61	0.47	0.15	+ 48	— 22	
320	9	26	10.5	10.52	0.11	0.13	— 47	— 35	AI
323	38	28	11.0	10.89	0.27	0.23	— 28	— 19	
325	23	10	8.5	8.62	0.06	—0.09	+ 45	— 1	B8
328	26	9	9.2	9.26	0.06	—0.13	— 81	+ 22	
334	65	43	13.2	12.79	0.50	0.16	— 31	— 67	
339	28	15	9.4	9.54	0.03	—0.14	— 23	— 10	B9
340	70		13.6	12.99	0.70	0.23	— 26	+ 16	
354	29	14	9.8	9.74	0.24	0.21	— 22	— 34	
368	60		12.9	12.53	0.53	0.13	+ 4	— 48	
355	78		14.1	13.58	0.63	0.04	— 87	— 67	
370	6		18.7	8.83	0.02	—0.09	— 21	+ 39	
373	37	25	10.8	10.72	0.27	0.27	— 17	— 63	
377	42	32	10.6	11.37	0.42	0.13	— 72	+ 32	
385	7	11	18.6	8.84	—0.04	—0.15	— 86	+ 18	B9
386	54	40	12.8	12.28	0.61	0.11	— 84	— 64	
392	53	42	12.6	12.16	0.54	0.00	— 98	— 70	
394	46	35	11.7	11.52	0.36	0.11	— 8	+ 11	
402	57	41	12.9	12.40	0.59	0.04	+ 7	— 23	
401	19		13.4	12.92	0.57	0.12	— 29	— 31	
405	50	36	12.0	11.73	0.37	0.08	— 36	— 14	O
410	33	23	10.2	10.15	0.22	0.08	— 40	— 69	A2
415	30	13	9.6	9.82	—0.02	—0.13	— 47	— 38	B9
421	16	23	12.4	11.76	0.71	0.17	+ 53	— 21	
423	39		11.3	11.16	0.33	0.08	— 5	— 9	
425	40	30	11.6	11.23	0.47	0.04	— 2	— 44	
446	22	5	7.7	7,95	—0.04	—0.42	— 78	— 5	B8
460	44	31	11.6	11.44	0.31	0.22	— 39	— 81	A5
469	32	16	9.8	9.98	0.00	0.04	+ 38	+ 39	
476	58		13.0	12.45	0.69	0.30	— 35	— 71	
481	69		13.5	12.96	0.68	0.21	+ 3	— 82	
542	43		11.6	11.38	0.38	0.38	— 4	— 52	
266	4	7	9.0	7.99	1.12	1.12	— 13	+ 14	KO

a selection of cluster members. In all, three stars of late spectral class appeared to be background stars based on the color excess. According to Zug, the average color excess in the region of the sky occupied by the cluster NGC 1502 appeared to be equal to $0^m.80$.

Three-color UBV photometry of the stars in the region of the cluster NGC 1502 was carried out by A. A. Hoag, H. L. Johnson, B. Iriarte, R. I. Mitchell, K. L. Hallam, and S. Sharpless. The results of their work are presented in the catalogue of the Washington Observatory [16]. In this catalogue there are contained in all 68 stars in the region of the sky under discussion, scattered

over a rather large area; several stars within the apparent boundaries of the cluster are not covered by the photometric investigations.

For various reasons 14 of the 68 stars were not measured by us. Therefore selection of cluster members based on the criterion of proper motion of the stars was carried out by us for only 54 stars which had accurate three-color photometry on the UBV system. In the paper [7] the cluster NGC 1502 was investigated along with other clusters. Below some data are presented for the cluster NGC 1502 from this paper:

m - M	R	$E_{(B - V)}$	$(B - V)_T$	S_p
$9^m.7 \pm 0^m.4$	880	$0^m.77$	$-0^m.29$	B O

(here the notations are the same as in Tables 1 and 5); as is evident, the cluster NGC 1502 appears to be very young based on $(B - V)_T$ and the spectral type S_p. Hopmann [4] considers the maximum age of this cluster to be of the order of 5×10^6 years.

According to the paper [7], the value of the insterstellar absorption in the region of the sky occupied by the cluster NGC 1502 varies within the limits $0^m.68$-$0^m.84$. Therefore prior to carrying out the selection of cluster members from background stars, we investigated the distribution of color excesses over regions of the sky, for which the three-color UBV photometric data presented in the catalogue of the Washington Observatory [16] was used.

With the aid of Johnson's nomogram [18] for the quantities B - V and U - B, we found the color excesses for each star. One can apply this nomogram only to stars of the main sequence of spectral class earlier than AO. Meanwhile not all the stars measured by us had spectral data available. Therefore at first we selected stars which were suitable on the two-color diagram for application of Johnson's nomogram and then arranged the individual color excesses obtained in the system of coordinates measured by us over the area of the sky occupied by the cluster. In order to lessen the effect of accidental errors on the determination of the individual color excesses, the region of the sky occupied by the cluster was divided into small sections, and in each section the average value of $E_{(B - V)}$, i.e., $\overline{E}_{(B - V)}$, was taken.

The final results are presented in Table 7 and in Figure 10, where x and y /16 are the average values of the rectangular coordinates of the stars located in the given section of the sky (they are expressed in minutes of arc and referred to the point having equatorial coordinates $\alpha_{1950.0} = 04^h03^m.4$, $\delta_{1950.0} = +62°12'$); $\overline{E}_{(B-V)}$ is the average value of the color excess in the given section, and ϵ is its probable error.

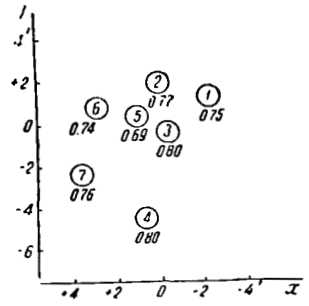

Figure 10. Distribution of the color excesses in the region of the cluster NGC 1502.

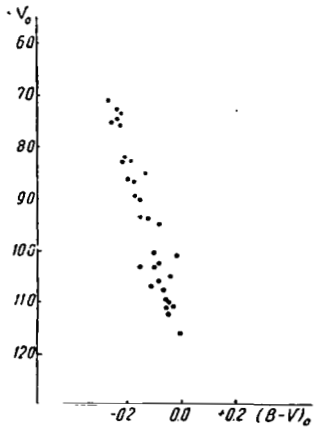

Figure 11.

We calculated the probable error on the basis of the deviations of the individual $E_{(B-V)}$ values from the average value of the color excesses for the stars situated in the corresponding section. In Figure 10 each section

TABLE 7

Section No.	Number of stars	x	y	$\overline{E}_{(B-V)}$	ϵ
1	3	−2.3	+1.5	$0^m.75$	$\pm 0^m.02$
2	4	+0.1	+2.1	0.77	±0.01
3	5	−0.3	−0.4	0.80	±0.01
4	5	+0.7	−4.5	0.80	±0.02
5	5	+1.0	+0.5	0.69	±0.01
6	4	+2.8	+0.8	0.74	±0.02
7	4	+3.8	−2.3	0.76	±0.01

is surrounded by a circle whose center corresponds to the average values of the rectangular coordinates of the stars of each section. The number of the section is inscribed in the circle, and under it, the value of $\overline{E}_{(B - V)}$. As is evident from Figure 10 and Table 7, although the investigated region of the sky is small (of the order of 10'), the distribution of absorbing material situated between the sun and the cluster NGC 1502 is rather nonuniform.

The selection of cluster stars was carried out by the investigators using approximations. At first the cluster members were selected from the color-stellar magnitude diagram. Thereupon the diagram was constructed after correction of the V and B - V values for each star for interstellar reddening and total light absorption. The $[V_0, (B - V)_0]$ diagram for the stars finally selected as members of the cluster under investigation is given in Figure 11. /17

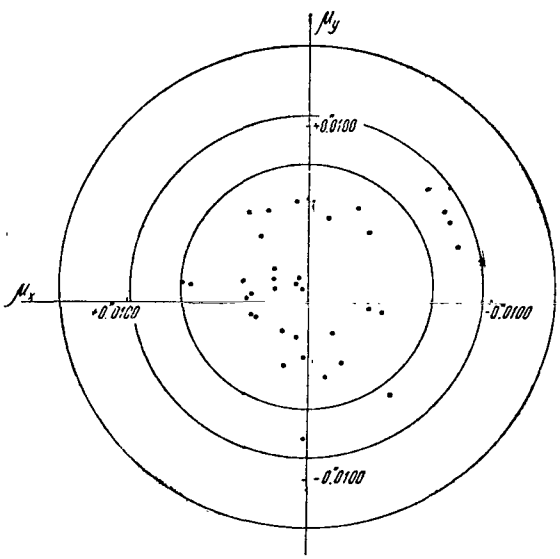

Figure 12.

On the initially constructed $[V_0, (B - V)_0]$ diagram 40 stars were situated along the main sequence. In order to consider them as cluster members with assurance according to the photometric criterion, we carried out an additional selection of cluster members from the background stars on the basis of their individual color excesses. Thereupon the stars 161, 164, 152, and 180 of our catalogue turned out to be background stars; one can assign the remaining 36 stars to cluster membership with assurance on the basis of the photometric criterion.

The final selection of cluster members among the 36 stars was carried out on the basis of their proper motions. As a result, 35 stars turned out to be cluster members. The vector diagram for the cluster members is presented in Figure 12, and a list of them is given in Table 8, in which $No._I$, $No._Z$, and $No._W$ denote the numbers of the stars from the

papers [3],[14], and [16], respectively; m_I is the photographic stellar magnitude in the international system [1]; V_0 and $(B - V)_0$ are the stellar magnitude and the color index corrected for reddening and total light absorption [16]; $E_{(B - V)}$ is the color excess; μ_x and μ_y are the annual proper motion expressed in 0".0001 [3]; and S_p is the spectral type of the star according to Trumpler.

The relative proper motion of the cluster NGC 1502 was obtained as the average of μ_x and μ_y of the individual stars (Table 8); it turned out to be equal to:

$\overline{m}$	$\overline{\mu}_x$	$\overline{\mu}_y$	Number of stars
$12^m.1$	+0".0001	+0".0009	35
	±0".0003	±0".0003	

/18

where $\overline{m}$ is the average stellar magnitude of the cluster members.

TABLE 8

№I	№Z	№W	m_I	V_0	$(B-V)_0$	$E_{(B-V)}$	μ_x	μ_y	S_p
219		3	9.8	7.58	−0.23	+0.66	+0.0005	+0.0014	
161	8	5	10.0	7.24	−0.24	+0.79	− 9	− 41	B5
147	7	6	10.1	7.14	−0.27	+0.84	+ 3	− 31	B3
156	10	7	10.2	7.46	−0.24	+0.78	+ 14	− 36	B3
186		57	14.4	11.62	0.00	+0.71	− 33	+ 40	
171	37	47	13.9	10.76	−0.11	+0.84	− 78	+ 49	
191	33	19	13.4	10.30	−0.10	+0.82	+ 19	+ 19	
158	26	16	12.9	10.31	−0.16	+0.71	− 27	+ 53	B8
152		53	14.2	11.02	−0.05	+0.83	− 40	− 5	
178	13	10	11.2	8.29	−0.19	+0.81	+ 2	− 78	B5
212	44	52	14.0	11.10	−0.03	+0.76	+ 36	+ 13	
217	42	50	14.0	11.11	−0.05	+0.75	+ 30	− 8	
202	46	23	14.2	11.19	−0.05	+0.79	− 33	− 3	
197	20	14	12.1	9.37	−0.15	+0.74	+ 7	+ 58	
164	36	43	13.6	10.52	−0.04	+0.80	− 44	− 52	A0
159	9	27	9.6	6.55	−0.22	+0.85	+ 66	+ 11	B3
149	14	8	10.9	8.33	−0.22	+0.72	+ 19	+ 9	B4
181		41	13.2	10.74	−0.07	+0.67	+ 71	+ 12	
204	17	31	11.2	8.51	−0.13	+0.74	+ 3	+ 9	B8
168		34	11.6	9.00	−0.15	+0.71	− 83	+ 32	
195	25	33	11.4	8.25	−0.21	+0.87	− 65	+ 65	B7
208	6	28	9.7	7.48	−0.26	+0.66	+ 15	− 17	B2
196	11	29	10.2	7.36	−0.23	+0.79	− 11	+ 49	B3
185	23	36	11.9	9.43	−0.13	+0.69	− 74	+ 52	B8
167	32	40	13.2	10.60	−0.09	+0.71	+ 27	+ 38	
182	18	35	11.5	9.25	−0.18	+0.65	+ 22	+ 54	B6
132	28	15	12.8	10.09	−0.02	+0.72	+ 33	+ 52	B9
137	30	38	13.1	10.08	−0.11	+0.82	+ 32	+ 5	B2
165	16	32	11.2	8.66	−0.18	+0.72	+ 19	+ 14	B8
142	15	9	11.1	8.62	−0.20	+0.70	+ 32	− 7	B2
157	19	13	11.9	8.93	−0.17	+0.82	+ 6	+ 11	
194	27	17	13.1	10.25	−0.09	+0.76	+ 34	+ 3	
151	43	49	14.0	10.96	−0.06	+0.80	+ 7	− 20	
172	22	12	11.8	9.11	−0.17	+0.75	− 13	− 17	
133	29	37	12.8	9.79	−0.08	+0.81	− 18	− 34	

Hopmann [4] determined the proper motions of 146 stars to the 13th photographic magnitude in the cluster NGC 1502 and its surroundings. As observational material he used the following: first epoch, five plates obtained at the Washington Observatory in 1906; second epoch, two photographs taken with the normal astrograph at Vienna, and four photographs taken in 1955 with the 10-cm refractor of the McCormick Observatory.

He found the average error of the proper motions of the stars to be of the order of ±0".004 in x and ±0".005 in y. According to Hopmann, 25 stars appeared to be cluster members, of which he considers the cluster membership of 6 stars to be doubtful. For the remaining 19 definite cluster members the following was obtained:

$$\mu_x = +0''.0011, \quad \mu_y = +0''.0100.$$

Cluster NGC 7380. The diffuse star cluster NGC 7380 ($\alpha_{1950.0} = 22^h44^m.9$, $\delta_{1950.0} = +57°52'$) is located in the constellation Cepheus. The probable errors of the proper motions of the stars in this region were found to be the same as in the case of the cluster NGC 1502, i.e., $\varepsilon_x = \pm 0''.0031$, $\varepsilon_y = \pm 0''.0035$. The radii of the concentric circles on the vector diagram of the proper motions are equal, respectively, to: $r_1 = 0''.0069$, $r_2 = 0''.0098$, $r_3 = 0''.0138$. /19

The proper motions of the stars in this region were determined by Li Hen [5]. For this he used one pair of plates with a difference in epoch of 16 years. According to the distribution of the star density in the region of the sky occupied by the cluster, Li Hen estimated the apparent angular size of the cluster NGC 7380 and carried out a selection of cluster members. In order to isolate the cluster from the background stars he applied Ebbighausen's method [6] and took as the value of the radius of the circle in the vector diagram

$$r = \sqrt{|\bar{\mu}_x|^2 + |\bar{\mu}_y|^2},$$

where $\bar{\mu}_x$ and $\bar{\mu}_y$ are the averages of the proper motions of the stars located within the apparent boundaries of the cluster. To the first approximation this is the proper motion of the cluster.

Li Hen did not give a list of cluster members. We present below some data from this paper:

Number of cluster stars	$\bar{\mu}_x$	$\bar{\mu}_y$	r	m	Angular diameter
54	+0".0009	+0".0015	0".0127	$13^m.2$	9'

In the catalogue [16] for the stars in the region of the cluster NGC 7380 are given the results of three-color photometry of 132 stars to the 16th photovisual stellar magnitude, of which we measured 58 stars; the remaining 74 stars were not contained on our photographs. In the paper [7], as was mentioned above, the UBV photometry of 106 diffuse star clusters was investigated. We present some data from this paper for the cluster NGC 7380:

m - M	R	$E_{(B-V)}$	$(B-V)_T$	S_p
$16^m.6 \pm 0^m.3$	2100	$0^m.58$	$-0^m.30$	09

According to $(B - V)_T$ and the spectral type S_p one can assign the cluster NGC 7380 to the category of the very young, with an age close to 10^6 years. According to the paper [7], the value of the interstellar absorption in the area of the sky occupied by this cluster varies within the limits of $0^m.50$ to $0^m.78$. Therefore, prior to carrying out a selection of cluster members from background stars, we investigated, as in the case of NGC 1502, the distribution of color excesses over the sections of the sky occupied by the cluster. The results are presented in Table 9 and in Figure 13, where the notations are the same as in Table 7. Then the stellar magnitudes V and color indices B - V of each star were corrected for the reddening and total light absorption corresponding to the star.

The color-stellar magnitude diagram $[V_0, (B - V)_0]$ based on corrected values of V and B - V for the stars which are definite cluster members is presented in Figure 14. Basing our work on a similar diagram for all stars having UBV photometry and proper motions as well as on the individual color excesses, we carried out the selection of cluster members. Thirty stars were located on /20 the main sequence of this $[V_0, (B - V)_0]$ diagram. According to the color excesses, they also belong to the cluster.

Selection of cluster members by Ebbighausen's method showed that stars 453, 454, 488, 495, and 509 can be taken as background stars, since they are located on the vector diagram outside the circle of radius $r_3 = 2\sqrt{2\sigma}$. The remaining 25 stars can be considered to be definite cluster members. The location of

the cluster members in the vector diagram is shown in Figure 15. A list of these stars is given in Table 10, where the numbers of the stars according to the catalogue [16] are presented in the graph as No.$_W$. The remaining notations are the same as in Table 8.

TABLE 9

Section No.	Number of stars	x'	y'	$\overline{E}_{(B-V)}$	ε
1	2	−9.9	−4.0	$0^m.64$	$\pm 0^m.04$
2	5	−4.2	−1.7	0.59	±0.02
3	4	−1.4	+0.1	0.57	±0.03
4	4	−0.4	+3.0	0.63	±0.02
5	7	+0.4	−3.0	0.60	±0.02
6	7	+2.3	+0.9	0.62	±0.03
7	2	+2.7	−3.3	0.76	∓0.02

Stars 453 and 454, which are located within the apparent boundaries of the cluster, appear to be components of a binary. Based on the photometric data and the spectral class (O6) one can take them to be cluster members. However, the proper motions of the stars deviate significantly from the proper motion of the cluster. Therefore, according to the criterion for selection of cluster members according to the proper motions of the stars,

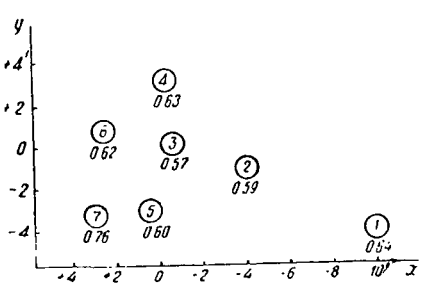

Figure 13. Distribution of color excesses in the region of the cluster NGC 7308 [sic].

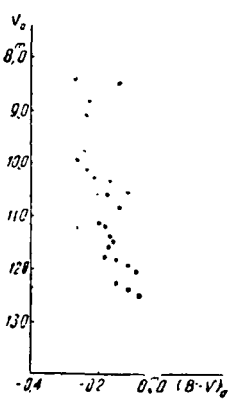

Figure 14.

stars 454 and 453 cannot belong to the cluster. Below we present some data on these stars:

No. I	m	μ_x	μ_y
453	$9^m.3$	+0".0163	-0".0551
454	$7^m.9$	+0".0126	-0".0696

As always, the relative proper motion of the cluster NGC 7380 was found as the average of all the μ_x and μ_y of the individual cluster members, i.e. the stars included in Table 10: /21

$\bar{m}$	$\bar{\mu}_x$	$\bar{\mu}_y$	Number of stars
$13^m.0$	+0".0021	-0".0018	25
	±0.0003	±0.0003	

Absolute proper motions and tangential velocities of the clusters.

The relative proper motions obtained above for the clusters NGC 7788, NGC 7790, NGC 2422, NGC 1502, and NGC 7380 were converted into absolute values by a statistical method. Using the well-known distances and radial velocities (for the clusters NGC 1502 and NGC 7380) of the cluster under discussion we calculated from the equations

$$\mu_x = \frac{x_\odot \sin\alpha - y_\odot \cos\alpha}{kr} + \mu_x',$$

$$\mu_y = \frac{x_\odot \cos\alpha \sin\delta + y_\odot \sin\alpha \sin\delta + z_\odot \cos\delta}{kr} + \mu_y',$$

$$V_r = V_r' + V_0 \cos\lambda$$

the corrections of the absolute proper motions and radial velocities of the clusters for the motion of the sun in space. Here $x_\odot$, $y_\odot$, $z_\odot$ are the projections of the velocity of the sun on the coordinate axes x, y, z, respectively, where the X-axis is directed towards the point of the vernal equinox, the Y-axis lies in the plane of the equator 90 degrees away in the direction of increasing right ascension, and the Z-axis is directed towards the North Pole; α, δ are the equatorial coordinates of the cluster; r is the distance to the cluster in parsecs; k = 4.738; μ_x, μ_y are the peculiar motions of the

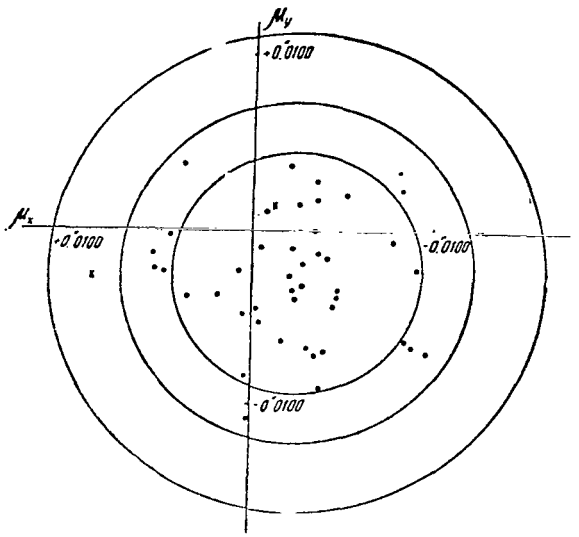

Figure 15.

clusters; V_r is the radial velocity; V_r' is the peculiar radial velocity; $V_0 \cos \lambda$ is the parallactic part of the radial velocity V_r; and λ is the angular distance of the clusters from the apex. /22

Thereupon the standard coordinates of the apex and velocity of the sun were taken (A = 270°, D = +30°, $V_\odot$ = 19.5 km/sec), and the radial velocities of the clusters NGC 1502 and NGC 7380 were taken from the paper [19]. The tangential velocities were calculated from the equation

$$V_t = 4.738\,\mu \cdot r,$$

TABLE 10

№ I	№ W	m I	V_0	$(B-V)_0$	$E_{(B-V)}$	μ_x	μ_y
319	72	$14^m.5$	$12^m.31$	$-0^m.15$	$0^m.62$	−0.0056	−0.0006
450	77	14.8	12.42	−0.10	0.64	+ 62	− 46
525	16	13.7	10.84	−0.13	0.78	+ 31	+ 30
358	68	14.4	11.54	−0.24	0.81	+ 7	− 72
398	38	12.0	10.16	−0.26	0.57	+ 32	− 16
527	32	10.9	8.39	−0.30	0.73	+ 29	+ 17
374	41	12.3	9.97	−0.29	0.63	+ 2	+ 12
474	64	14.2	11.80	−0.15	0.68	+ 64	+ 49
437	63	14.2	11.77	−0.19	0.69	+ 64	− 14
357	25	15.0	13.27	+0.03	0.47	+ 25	− 2
380	15	13.4	11.50	−0.16	0.54	+ 4	− 28
397	67	14.4	11.94	−0.10	0.67	+ 42	+ 43
472	37	12.0	9.79	−0.27	0.65	− 17	− 73
392	12	12.4	10.60	−0.18	0.53	+ 36	− 14
426	40	12.1	10.28	−0.23	0.56	− 12	− 50
409	8	10.8	9.08	−0.26	0.53	+ 1	− 32
493	43	12.3	10.35	−0.17	0.57	+ 51	− 14
526	4	10.4	8.49	−0.14	0.54	+ 44	− 70
492	59	14.1	11.14	−0.14	0.82	− 6	− 62
489	9	10.9	8.85	−0.25	0.61	+ 50	+ 28
480	54	13.8	11.23	−0.19	0.72	− 12	− 4
402	44	12.4	10.59	−0.22	0.54	+ 15	− 49
417	22	14.6	12.07	−0.08	0.67	− 36	− 76
449	23	14.7	12.49	−0.06	0.61	− 30	− 61
442	13	13.2	10.58	−0.10	0.71	+ 19	+ 41

where μ is the total peculiar proper motion of the cluster expressed in seconds of arc. The results obtained are presented in Table 11, where μ_x, μ_y are the components of the absolute annual proper motion of the cluster; μ_{xp}, μ_{yp} are the same corrected for the motion of the sun; μ_p is the total amount of the peculiar proper motion; Q is the position angle of the peculiar motion calculated from north towards east; V_t, V_r, V are the tangential, radial, and space peculiar velocities expressed in kilometers per second.

TABLE 11

Cluster	μ_x	μ_y	μ_{xp}	μ_{yp}	μ_p	Q	R	V_t	V_r	V
NGC 7788	−0.″0015	−0.″0022	−0.″0030	−0.″0018	0.″0035	219°	2410	40		
NGC 7790	−0.0014	−0.0025	−0.0024	−0.0022	0.0033	226	3600	56		
NGC 2422	−0.0064	−0.0008	−0.0034	+0.0017	0.0038	157	480	9		
NGC 1502	+0.0018	−0.0033	+0.0002	+0.0009	0.0009	42	880	4	−16	16
NGC 7380	+0.0005	−0.0041	−0.0011	−0.0041	0.0042	257	2100	42	−24	48

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